NOTES ON THE WATER SUPPLIES OF ARMY CAMPS, CANTONMENTS AND POSTS IN THE UNITED STATES, WITH PARTICULAR REFERENCE TO PROBLEMS OF QUALITY[1]

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The expansion of the military establishment following our entrance into the war necessitated an immense program of building in order to provide housing and accommodations for the new army during its organization and training. The first plans provided for 32 camps divided into two classes, 16 for the accommodation of drafted men, designated as national army camps, and 16 for the accommodation of the federalized state militia, designated as National guard camps. It was presumed that the period of the occupancy of the latter would be relatively short on account of the advanced training of the national guard, and they therefor were not constructed in as permanent a manner as the national army camps. Consequently they were generally located in the southern portions of the country in order to take advantage of the milder climate. They were commonly known as tent camps, and were not provided with water-carriage sewerage systems, heating plants, laundries, and other conveniences, and their water works plants and water distribution systems were not designed in as generous a manner as were those of camps of the first class.

Before the completion of any of the original 32 camps it became apparent that there were many other projects necessary to be undertaken, such as extensions to the camps then being built, the enlargement or improvement of many regular army posts, the construction of additional camps for special training purposes, the erection of quartermaster and ordnance depots, port terminal facilities, chemical warfare camps, explosive plants, the construction of new hospitals and the improvement or remodeling of privately owned buildings taken over for hospital purposes, and many other miscellaneous pieces of construction.

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It is estimated that the separate projects handled in the United States by the War Department reached a total number in excess of 600. Many of these projects included complete water works plants and sewer systems. Whenever possible the water supply of nearby cities was utilized, and, when necessary, sufficient aid was given by the government to the cities or to the companies operating the plants, for the rehabilitation or the enlargement of their works, so that the desired service could be furnished. In addition to the projects undertaken by the War Department organizations, there were many others of similar nature undertaken by the Navy Department, the Shipping Board and the Housing Corporation.

The construction problem in general. It is difficult to realize the magnitude of the problem with which those in authority were confronted in April, May, June and July, 1917. There was little or no knowledge of the sites on which many of the camps were to be built, of their topography or of their distance from transportation lines. The ultimate size of the company and regimental units was not even known, (on account of changes which had been proposed in order to coordinate our army with those of the Allies) although it had been decided that each camp should house one infantry division and certain other special troops. It was proposed to call the first draft to camp about September 1, and it was necessary to have ready for them at that time not only the 1200 to 1500 buildings needed, but to have complete and reliable utilities including water supply, sewerage and electricity. This necessitated the complete construction of 32 new cities, each of from 30,000 to 40,000 population, beginning with the clearing of the site and carried through to the completed project, in the short time of about ninety days, and it was also necessary to provide temporary shelter and accommodations, including water supply, for a large number of workmen at each camp, during the construction period.

Upon the declaration of war in April, 1917, the Council of National Defense was formed, and various committees of this Council immediately co-operated with the then small Cantonment Division of the army, which had just been formed from the Construction and Repair Division of the Quartermaster General's Department, in the preparation of typical plans for camps, buildings and utilities, the selection of contractors and engineers, and many other matters pertaining to the construction work at hand. A constructing quartermaster for each camp was appointed and a civilian engineer from

the same general locality as the camp, who was familiar with local conditions, was chosen as assistant to the constructing quartermaster. He was given the title of supervising engineer.

After the actual choosing of a camp site, which in the cases of most of the earlier camps was done by the commanding officer of the department in which the camp was to be located, assisted by a board of officers of the regular army, the constructing quartermaster and the supervising engineer fitted the typical plans with which they had been furnished to the proposed site. They also reported upon the available sources of water supply, the best means of disposing of sewage and upon all other features of the camp of an engineering nature. Advisory engineers, stationed in the Washington Office, in general charge of various portions of the work, had been appointed in the Cantonment Division. Through the co-operation of all of these men the camps were developed and constructed.

During this period aviation camps were being established and constructed, independently of the Cantonment Division, under the supervision of the Buildings and Grounds Section, Department of Military Aeronautics. Their water supply, sewerage, sewage disposal and similar problems were usually handled by the engineers from that department, assisted by civilian engineers generally chosen from the vicinity of the camp. Many special training camps, and other camps for specific purposes were soon established and under way, usually under the supervision of the Cantonment Division, which meanwhile had been separated from the Quartermaster Corps and reorganized as an independent branch of the army under the name of Construction Division. The utilities of these later camps were in most cases designed and constructed entirely under the direction of representatives of this division. Many of the camps, plants and hospitals were unsatisfactorily located from the standpoint of sanitation, and their water supply, sewerage and drainage problems were unusually difficult, but the sites were considered by those in authority so advantageous from other standpoints that the sanitary objections were overruled.

Sources of water supply utilized. The first camp sites were chosen as stated before, by the commanding officers of the department in which they were to be located, assisted by a board of officers upon which there were supposed to be five men, including an engineer, a medical officer, a quartermaster corps officer and two line officers, but the boards which passed upon the numerous sites offered did

not in all cases have a complete representation, and the inspections in many cases were made by only one or two of the officers of a board. In several cases, the recommendations of the officers assigned to this duty were ignored by the department commander and camp sites were chosen over the objections of the board. A great many features required consideration in connection with the choice of the sites. Of these sanitation, including water supply, sewerage and drainage, although of recognized importance, was only one. Therefore in many instances the problem was considerably complicated and it was necessary ultimately to choose sources of water supply which would not have been considered, had sites, more appropriate from this standpoint, been selected, or had more time been available for prospecting for or for the development of, other sources of supply. This was the case, for instance, at Camp Dix, where one of the strong arguments advanced for the site near Wrightstown was the abundant supply of wholesome well water, said to be easily available in the vicinity of the camp. After a hurried but capable investigation by experts, a supply of easily purified surface water from Rancocas Creek of undoubted adequacy was chosen rather than an apparently limited supply from wells. At Camp Pike also, the city supply of Little Rock with the Arkansas River as its source, necessitating 6 miles of pipe line and two booster stations to get the water into the camp, was chosen rather than risk the development of a ground water supply, which probably would have been highly impregnated with iron, although available in a somewhat closer location to the camp.

In all there were 48 large camps. This number includes the original 32 national army and national guard camps, 9 special training camps, 3 embarkation camps, 3 port terminals and one large arsenal. This number does not include any of the aviation camps, ordnance plants, or numerous other camps and plants of smaller size. Data concerning the ownership and the general source of supply, whether ground water or surface water, are shown in tables 1 and 2. Information of the same sort concerning 21 other smaller training camps, proving grounds, ordnance or other plants is shown in table 3. This latter list is by no means complete but represents principally those places in which some work was done by officers of the Sanitary Corps. Table 4 contains the same data for all of the general hospitals and table 4 A for all of the aviation camps.

Bearing in mind the fact that the original intention was that the national guard camps should be of more temporary character than

TABLE 1

Data relating to ownership and type of source of water supply of original 32 national army and national guard camps

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Beauregard*	Dix§	Cody* (Deming, N. M.)¶	Bowie* (Ft. Worth)‡‡
Custer	Meade	Fremont* (San Francisco)**	Doniphan* (Lawton)
Devens†		Logan* (Houston, Tex.)††	Gordon (Atlanta)
Dodge		McClellan* (Anniston)	Greene* (Charlotte)
Funston		Sheridan* (Montgomery)	Hancock* (Augusta)
Grant		Travis, San Antonio	Jackson (Columbia)
Lewis			Kearney* (San Diego)§§
Shelby*			Lee (Petersburg)
Sherman‡			McArthur* (Waco)¶¶
Upton			Pike (Little Rock)†††
			Sevier* (Charlotte)
			Wadsworth* (Spartanburg)
			Wheeler* (Macon)***

* Indicates national guard camps.
† Emergency connection to Ayer waterworks (ground water).
‡ Emergency connection to Chillicothe waterworks (ground water).
§ Auxiliary well supply for boiler use and for base hospital.
¶ 2 wells owned by United Land and Water Company.
2 wells owned by Government.
** Camp distribution system connected to Bear Gulch reservoir.
†† Auxiliary wells owned by Government.
‡‡ Main supply from Lake Worth. An auxiliary well supply is available.
§§ Auxiliary supply from wells.
¶¶ Forty per cent of water from Brazos River, 60 per cent from wells.
*** Auxiliary supply from Stone Creek.
††† Auxiliary well supply.

TABLE 2

Data relating to ownership and type of source of water supply of miscellaneous large army camps constructed after the completion of the original 32 camps

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Eustis	Benning	Mills*	Charleston port terminal
Johnston	Bragg		Forrest, Greenleaf } Chattanooga†
Stanley	Edgewood		Las Casas (San Juan)
	Knox		Merritt (Hackensack Water Co.)
	Humphreys		Newport News
			1. Alexander
			2. Hill
			3. Morrison
			4. Stuart
			Norfolk Port Terminal

* Government owned ground water supply was developed in 1919.

† Auxiliary supply from Fort Oglethorpe, wells.

TABLE 3

Data relating to ownership and type of source of water supply of miscellaneous small camps and plants

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Aberdeen Proving Grounds	Muscle Shoals	Willoughby	Colt (Gettysburg)
Curtis Bay Ordnance Depot	Perry	Hastings	Crane (Allentown)
Holabird	Summerall	Raritan	Jessup (Atlanta)
Kendrick			Kingsport (Kingsport)
Normoyle			Laurel (Laurel)
Pig Point Arsenal			Leach (Washington)
Robinson			Meigs (Washington)
Savannah Proving Grounds			Syracuse (Syracuse)

This list is by no means complete but it is believed that the more important of the small plants are included.

TABLE 4

Data relating to ownership and type of source of water supply of aviation fields

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Barron, Ft. Worth, Tex.	Langley, Hampton, Va.	Arcadia Balloon School, Cal.	Bolling, Washington, D. C.
Carlstrom, Arcadia, Fla.	Selfridge, Mt. Clemens, Mich.	Brooks, San Antonio	Call, Wichita Falls, Tex.
Carruthers, Ft. Worth, Tex.	Ground water	John Wise, San Antonio	Vail, Tintern Manor, N. J.
Dorr, Arcadia, Fla.		Chanute, Rantoul, Ill.	Hazelhurst, Garden City, L. I.
Eberts, Lonoke, Ark.	Taliaferro, Ft. Worth, Tex.	ARD, Montgomery, Ala.	Post, Lawton, Okla.
Ellington, Houston, Tex.	Taylor, Montgomery, Ala.	Houston GSD, Tex.	Rich, Waco, Tex.
Gerstner, Lake Charles, La.	McCook, Dayton, Ohio	Emerson, Columbia, S. C. (not city supply)	Rockwell, Coronado W. Co. (San Diego)
Lee Hall Balloon School, Va.	MiddletownAGSD Pa.	Kelly, San Antonio	Scott, E. St. Louis, Ill.
Love, Dallas, Tex.	DaytonWarehouse Ohio		Morrison, ASD, Newport News, Va.
March, Riverside, Cal.	ARD, Dallas, Tex.	Surface water	Omaha Balloon School, Omaha, Nebr.
Mather, Sacramento, Cal.	ARD, Indianapolis	Chandler, Essington, Pa.	Little Rock Warehouse, Ark.
Miami AGS, Fla.	Detroit Acceptance Park, Mich.	Buffalo Acceptance Park, N. Y.	Elizabeth, N. J. Acceptance Park
Mitchell, L. I.	Rockwell Park, Wilmington, Del.	Penn, Austin, Texas	
Park, Millington, Tenn.	Dayton Acceptance Park, Ohio	Richmond Warehouse, Va.	
Payne, West Point, Miss.	Dayton GSD, Ohio		
Souther, Americus, Ga.	Garden City, ASD, L. I.		
Wilbur Wright-Fairfield, Ohio			

TABLE 4A

Data relating to ownership and type of source of water supply of army general hospitals

GROUND WATER			SURFACE WATER		
Number	Place	Ownership	Number	Place	Ownership
	Hot Springs, Ark.*	City of Hot Springs		San Francisco*	Government
	Ft. Bayard, N. M.*	Government		Walter Reed, Washington*	District of Columbia
9	Lakewood, N. C.	Lakewood Water Co.	1	Williamsbridge N. Y.	New York City
11	Cape May, N. J.	City of Cape May	2	Ft. McHenry*	Baltimore
14	Ft. Oglethorpe*	Government	3	Colonia, N. J.†	Middlesex Water Co.
25	Ft. Benj. Harrison*	Government	4	Ft. Porter, N. Y.*	City of Buffalo
26	Ft. Des Moines*	Des Moines, Ia.	5	Ft. Ontario, N. Y.*	City of Oswego
29	Ft. Snelling, Minn.*	Government	6	Ft. McPherson, Ga.*	City of Atlanta
34	East Norfolk, Mass.	Leased	7	Roland Park, Md.	Baltimore Co. Co.
SURFACE WATER			8	Otisville, N. Y.	New York City Hospital
			10	Boston, Mass.	Metropolitan District
38	East View, N. Y.	City of New York	12	Biltmore, N.C.	City of Asheville
40	St. Louis	City of St. Louis	16	New Haven, Conn.	City of New Haven
41	Fox Hills, N. Y.	City of New York	17	Markleton, Pa.	Leased
42	Spartanburg, N. C.†	City of Spartanburg	19	Oteen, N. C.	Asheville
			21	Denver, Col.†	City of Denver
			22	Philadelphia	Philadelphia
			24	Park View, Pa.	Pittsburgh
			28	Ft. Sheridan, Ill.*	Government
			30	Plattsburg Bks.*	Plattsburg W. Co.
			31	Carlisle, Pa.	City of Carlisle
			32	Chicago, Ill.	City of Chicago
			35	West Baden, Ill.	Leased
			36	Detroit, Mich.	City of Detroit

* Indicates regular army hospitals or permanent army posts utilized for hospital purposes.

† Indicates new establishment constructed by Government.

the national army camps, it is interesting to note that ten of the sixteen nationl army camps were supplied by new plants designed and constructed by the War Department, while the remaining six were supplied by existing plants of the nearby communities. Only two new plants were constructed for the National Guard camps, the remaining fourteen being supplied by plants of the nearby communities.

Scope and nature of the present discussion. The immediate purpose of this paper is to present a more or less general statement concerning the quality of the water supplied to troops in the camps in the United States, the agencies and the methods utilized for safeguarding the supplies and the results which were obtained. The subjects of quantity and dependableness will be touched but briefly, because, while these two attributes of a satisfactory supply have close relations to the quality, there were only a few instances where an abundant supply was not available at all times and the shortages which were experienced were of brief duration only.

The material presented herewith has been collected from many different sources, principally from monthly and special reports of camp sanitary engineers, the reports of sanitary inspections made by medical officers of the Division of Sanitation of the Medical Department, and the monthly sanitary reports made by the camp sanitary inspectors. Material from these sources has been supplemented by information gained through special investigations by the authors or other officers of the sanitary engineering section of the Surgeon General's Office and through official and unofficial correspondence with various persons and various branches of the service, particularly the Construction Division.

Relation of the Medical Department to the water supply problems. The army regulations charge the Medical Department "with the duty of investigating the sanitary condition of the army and making recommendations in reference thereto," and further "of advising with reference to . . . . the adoption of systems of water supply and purification . . . . etc." They further provide that "the surgeon of every post or command, under the direction of the commanding officer . . . . will examine, at least once a month, the amount and potability of the water supply . . . ." The reports of such examinations are received by the Surgeon General. They constitute a portion of the monthly sanitary reports referred to above.

A group of specially trained medical officers of long service, at-

tached to the Division of Sanitation, Office of the Surgeon General, is constantly engaged in making routine and special inspections and reports of all large camps, cantonments, hospitals and other stations, their duties pertaining chiefly to sanitary and administrative matters. Great stress is laid by these officers on matters largely technical, including among other things general camp sanitation, water purification and sewage disposal.

The Sanitary Corps of the army was authorized by the President on June 30, 1917, under the Medical Department and it was organized shortly thereafter. Officers were commissioned in this corps who were found "to possess special skill in sanitation, in sanitary engineering, in bacteriology or other sciences related to sanitation and preventive medicine . . . . etc."

The sanitary engineering section of the Sanitary Corps is composed of officers and enlisted men who have had special training in sanitary engineering and public health administration. In general the personnel of the section has been distributed in three groups; (a) those on duty in the Division of Sanitation, Surgeon General's Office; (b) those stationed at camps, cantonments and other commands in the field, and (c) those in overseas service as commanding officers of sanitary detachments and sanitary squads, water tank trains, on special duty with water supply companies of engineer regiments and in laboratory and other special work.

Those officers on duty in the Surgeon General's Office have acted as consultants, advisors and field inspectors on questions relating to water supply and its purification, sewerage and sewage disposal; drainage and mosquito control operations; the disposal of garbage, manure and camp wastes and other similar problems of sanitation.

The duties of the camp sanitary engineer are specified in a circular of the War Department as follows:

> The Sanitary Engineer is an assistant to the camp surgeon and his duties ordinarily shall be:
>
> (a) To inspect and supervise the operation of water supply, sewage and garbage disposal systems, and to advise the utilities officer and subdepot quartermaster with reference thereto; to recommend such suitable standards of performance of these systems as will properly conserve the interests of health and sanitation in the camp and its environment.
>
> (b) To have immediate charge, under the camp surgeon, of drainage, oiling and other preventive measures for the extermination of mosquitoes and flies.
>
> (c) To act as consultant and advisor to the camp surgeon on all the engineering or structural phases of the camp or station which bear a definite relation to health and sanitation.

(d) To perform such other sanitary duties as may be designated by competent authority.

(e) To render a monthly report to the Surgeon General of the army, through military channels, covering such subjects as may be prescribed by the Surgeon General.

Other officers of the Sanitary Corps have been on duty in the field in charge of mosquito and fly control work, in charge of drainage survey parties and as water and sewage plant operators. At some camps and in some municipalities supplying water to camps, these officers were directly in charge of the operation of the plants, although that duty as respects these government plants was usually performed by officers of the Utilities Branch of the Construction Division.

Consideration given to problems of quality in connection with development and construction of water works. The importance of a safe and an aesthetically satisfactory water supply was realized all through the planning and the development of the camps, and particular emphasis was laid on these features in the original instructions for choosing camp sites, issued to the department commanders by the Chief of Staff. As explained before, these matters were occasionally overruled and camp sites were chosen with unusually difficult water supply problems, but in each instance a great effort was made to provide equipment for satisfactorily treating the water in order to secure a safe supply. Willingness to expend large sums of money to accomplish this end was evident, and modern, up-to-date water purification plants were installed at camps where there was any question of contamination of the supply.

Some of the sanitary precautions upon which particular stress was laid by the advisory engineer on water supply of the Construction Division, in addition to the care exercised in the selection of the source of supply and the provision of water purification plants, were described in a recent paper by the advisory engineer on water supply, Construction Division, as follows:

(a) The covering of all storage reservoirs to prevent accidental or intentional pollution and the formation of algae.

(b) The furnishing of chlorinators to all cantonments and camps even when the supply might be regarded as normally safe.

(c) The prohibition of the use of wells in shallow strata on inhabited watersheds or in any other stratum or location in which it might be possible for the wells to become contaminated.

(d) The absolute prohibition of any distribution mains carrying polluted water, whether for fire protection, or industrial or any other use and of any

outlet or fixture from which such water might be drawn or of any arrangement that would permit the later introduction of any such outlet or fixture.

Consideration given to problems of quality in maintenance and operation of waterworks. Upon the completion of the first several of the large camps, the operation of the utilities at each place was undertaken by the camp quartermaster, assisted by a few specially selected officers commissioned directly from civil life for this work and a small group of enlisted men, following out in a general way the procedure which had prevailed for a long time in the regular army establishment. The work became so great and the problems so complicated, however, that in the summer of 1918 a new organization was formed, known as the Maintenance and Repair Branch of the Construction Division, which has since had charge of all the general utilities pertaining to the army, and of the maintenance and repair of all buildings, roads, walks, wharves, and water and sewerage work. This branch is separated from and independent of the Quartermaster Corps. A central office at Washington directs the work of the utilities organization at each camp. A great effort was made to secure a sufficient number of trained engineers and operators for the work.

The operation of the utilities at aviation camps at first was usually supervised by the government superintendent of construction after their completion, but this policy was later changed and maintenance officers were appointed at each post by the commanding officer, from the personnel at the post. He had general charge, with the assistance of the medical or sanitary corps officer, of water supply, sewerage, sewage treatment, etc. and worked under the general supervision of the Buildings and Grounds Section, Air Service Property Division.

The authority for supervision by the Medical Department over the quantity and quality of the water supply, and the duties of the camp sanitary inspector and the camp sanitary engineer, have been previously set forth, and these officers have exercised their functions in full coöperation with the officers of the Maintenance and Repair Branch and with those of the office of the advisory engineer on water supply. They have been available at all times for advice and consultation on all problems of a sanitary engineering nature.

Control of quality of surface water supplies. Twenty-seven of the 48 large camps were supplied with water from surface sources. Of these, fifteen utilized large streams or rivers, nine small streams or creeks and four impounding reservoirs. All of these with three ex-

ceptions, Camps Dix, Doniphan and Sevier, were equipped with rapid sand filters and disinfecting equipment for the treatment of the water. Camp Dix water is treated by chlorination alone, as it is taken from a small stream which is only moderately contaminated but never turbid. Camp Doniphan at Fort Sill, Okla., and Camp Sevier at Greenville, S. C., are both supplied from large impounding reservoirs with watersheds practically uninhabited. Chlorination has rendered the water at each place safe, but the occurrence of growths of microscopic organisms and occasional high turbidities in Lake Lawtonka, from which Camp Doniphan is supplied, has resulted in the installation there of rapid sand filters (1919). All of the government owned surface supplies for the smaller camps, aviation fields and hospitals were equipped with filters, as were practically all of the municipal surface supplies which were utilized by camps of this class.

Careful sanitary surveys were made of all watersheds, limited in the case of the large streams to that area lying within a few miles of the intake, but covering in the case of the smaller streams the entire watershed. Regular patrols of detachments of enlisted men were maintained on the smaller watersheds under the direction of the camp sanitary engineers, and unusual efforts were made, on a scale seldom even approximated in municipal practice, to secure the abatement of conditions deemed prejudicial to the quality of the supplies.

The actual operation of the government owned water works plants was usually conducted by the Maintenance and Repair Branch of the Construction Division, with a close and careful supervision by an officer of the Sanitary Corps. Municipal plants were usually operated by municipal employees with the same close supervision by the Sanitary Corps as was exercised in the case of government owned plants, but in several instances, notably Petersburg, Va., supplying Camp Lee; Augusta, Ga., supplying Camp Hancock; Lawton, Okla., supplying Camp Doniphan, Fort Sill and Post Field; and Watervliet, N. Y., supplying Watervliet Arsenal, the operation was actually performed by Sanitary Corps officers, and in many other instances the plants were supervised or operated under the direction of camp sanitary engineers. The Red Cross and the United States Public Health Service in their extra-cantonment work, also gave much valuable assistance in the operation of municipal plants through their laboratories and sanitary engineers.

Control of quality of ground water supplies. In general the supplies of water obtained from the ground for the use of our army camps

have been subjected to the same rigid tests as are those secured from sources naturally subject to more immediate and dangerous pollution. Where control measures have been deemed necessary, these have been applied in no uncertain fashion.

The difficulty in securing ground water supplies (especially from comparatively shallow water-bearing strata), which will give negative results with presumptive tests for B. coli is known to all experienced sanitary engineers. Such tests are unquestionably too severe in a vast majority of cases, and it is probable that many safe supplies have thereby been condemned and have been abandoned or else have been subjected to unnecessary treatment. Nevertheless, it is apparent that such tests must err on the side of safety and that they have the very real advantage of directing the attention of sanitary authorities to those supplies which do not demonstrate acceptability on that basis. In this way physical and other investigations may be undertaken which will show whether or not such waters are by any possibility subject to pollution and what means of control or remedy should be applied. Doubtless many perfectly safe ground water supplies of our army posts have been regularly or occasionally subjected to treatment by disinfection because of such laboratory findings. However, as stated hereafter, it has been the well defined policy of those having authority in such matters, to take absolutely no known or predictable chances as respects the hygienic safety of any water supply.

The physical conditions and factors affecting the quantity and quality of ground water supplies have received careful attention. Percolating or collecting areas, when not too remote, and geological formations have been investigated and thereby information has been secured in many cases whereby not only has it been possible to forecast the general quantity of water available but the probable quality of such supplies from chemical and bacteriological standpoints has become at least roughly manifest. In this connection the probable time factor or period of time required for water to pass from a collecting point or area to the point or place of withdrawal has been of extreme interest. It is not conceivable that a water passing through the ground can remain specifically infected through any continued interval even if the materials were negligible, which of course cannot ordinarily be the fact.

Much attention has been given to the elimination of sources of pollution in the neighborhood of ground-water collecting works, and

surface water has been carefully excluded by proper construction methods at all plants installed during the emergency.

Disinfection of water supplies. No great reliance was placed on the ability of filters to produce more than an aesthetically satisfactory water; consequently, disinfection by chlorination was instituted for every surface water supply as well as for every ground water of doubtful quality. A wealth of data is available in the army records as well as from civil experience to prove the necessity for this precaution. Table 5 has been prepared to present the situation as expressed by army experience. It contains a summary of a part of the data for Camp Meade, which is supplied with a coagulated, settled and filtered water from Little Patuxent River, a stream heavily polluted with sewage only a few miles above the camp water intake.

TABLE 5A

Record of bacterial efficiency, water purification plant, Camp Meade, Md.

Source of supply, Little Patuxent River; nominal capacity of filters, 3,000,000 gallons daily, rapid sand gravity type; capacity of coagulation and settling tanks, 400,000 gallons; coagulant used, Al_2SO_4.

1918 to 1919	TOTAL COUNT, AGAR, 37°, PER CUBIC CENTIMETER			BACTERIAL REMOVAL BY FILTERS	PRESUMPTIVE TESTS FOR B COLI				B. COLI CONFIRMED, CHLORINATED 10 CC.	AVERAGE CHLORINE DOSE
					Filtered water		Chlorinated			
	Raw	Filtered	Chlorinated		Number	Plus in 1 cc.	Number	Plus in 10 cc.		
				per cent		*per cent*		*per cent*		*p.p.m.*
February	970	64.0		93.4						
March	890	10.0	3.0	98.9						0.59
April	910	30.0	6.0	96.7	54	16.0				0.55
May	4800	78.0	5.0	98.4	61	26.0				0.55
June	760	42.0	4.0	94.5	46	24.0				0.58
July	700	44.0	2.0	93.7	79	6.0				0.55
August	2300	207.0	16.0	91.0	137	16.0				1.22
September	1080	31.0	5.0	97.1	360	37.5	360	16.5	0	1.28
October	318	24.0	3.0	92.0	370	10.8	116	0.8	0	1.09
November	434	82.0	8.0	81.0	372	17.4	144	9.7	0	1.07
December	1500	15.0	1.0	96.3	712	14.6	240	7.8	0	1.57
January	422	8.0	0.37	97.2	612	7.3	135	2.9	0	1.22
February	250	2.4	0.2	97.1	352	6.8	120	0.0	0	1.20
March	615	9.5	0.64	98.5	448	5.5	145	3.3	0	1.26
April	700	21.0	0.78	97.0	369	26.5	120	5.8	0	1.01
May	381	9.4	0.45	90.2	175	39.0	125	1.6	0	1.01

TABLE 5B

Record of bacterial efficiency, water purification plant, Fort Worth, Texas, supplying Camp Bowie

1918 TO 1919	TOTAL COUNT, NUTRIENT AGAR, 37.5°			BACTERIAL REMOVAL BY FILTERS	PRESUMPTIVE TESTS FOR B. COLI				B. COLI CONFIRMED, CHLORINATED, 10 CC.	AVERAGE CHLORINE DOSE
					Filtered water		Chlorinated			
	Raw	Filtered	Chlorinated		Number	Positive in 1 cc.	Number	Positive 10 cc.		
				per cent		*per cent*		*per cent*		*p.p.m.*
September	420	52	1500	80.7	30	0	30	0	0	1.05
October	307	57	565	81.4	29	20.7	29	0	0	0.77
November	1297	273	68	78.9	29	10.4	29	0	0	0.56
December	1096	280	52	95.3	31	3.3	31	0	0	0.60
1919										
January	1986	475	53	76.8	28	0	28	0	0	1.12
February	866	201	54	76.8	28	3.5	28	0	0	1.02
March	241	58	30	75.9	31	0	31	0	0	0.55
April	979	310	58	68.3	30	0	30	0	0	0.38
May	419	186	46		31	0	31	0	0	0.51

The filters have been very efficient in the removal of turbidity, since the water supplied the camp has practically always been clear and attractive, although very high turbidities are occasionally encountered in the raw water, but their efficiency has not been so satisfactory in the removal of bacteria. While the total number of bacteria (agar, 37°, twenty-four hours) present in the filtered water is well within the limits of the Treasury Department standard, which has been adopted as the army standard, B. coli was present with great frequency in 1 cc. samples, both in the presumptive and confirmed (not shown in table) tests. In the chlorinated water the total count was greatly reduced and B. coli was seldom found in 10 cc. by the presumptive test and the few thus found were practically never confirmed on Endo's medium.

Experience with waters only slightly polluted, in which B. coli appears occasionally in 1 cc., indicate the same inability of filters to produce a water which will regularly pass the standard even with most careful operation. This subject is not discussed with a desire to minimize the importance of filters, because their importance in water purification can hardly be assailed, but for the purpose of emphasizing the necessity of the final treatment, disinfection.

TABLE 6

Showing source, ownership and treatment of water supply of 48 large camps and cantonments

CAMP	NEAR	SOURCE OF SUPPLY	OWNERSHIP	FILTRATION*	CHLORINATION
Beauregard	Alexandria, La.	Wells	Government	None	Intermittent
Benning‡	Columbus, Ga.	Upatoi Creek	Government	Yes	Constant
Bowie	Fort Worth, Tex.	Trinity River	Municipal	Yes	Constant
Bragg‡	Fayetteville, N. C.	Little River	Government	Yes	Constant
Charleston P. T.	Charleston, S. C.	Goose Creek	Municipal	Yes	Constant
Cody	Deming, N. M.	Wells	Municipal and Government	No	Emergency
Custer	Battle Creek, Mich.	Wells	Government	No	Emergency
Devens	Ayer, Mass.	Wells	Government	No	Constant
Dix	Wrightstown, N. J.	Rancocas Creek	Government	No	Constant
Dodge	Des Moines, Ia.	Wells	Government	No	Constant
Doniphan	Fort Sill, Okla.	Lake Lawtonka	Municipal	Under construction	Constant
Edgewood	Edgewood, Md.	Winter's Run	Government	Yes	Constant
Eustis	Lee Hall, Va.	Wells	Government	No	Emergency
Forrest	Chickamauga Park	Tennessee River Chattanooga City Supply	Private Co.	Yes	Constant
Fremont	Palo Alto, Cal.	Galleries	Municipal	No	None †
Funston	Fort Riley, Kans.	Wells	Government	No	Constant
Gordon	Atlanta, Ga.	Chattahoochie River	Municipal	Yes	Constant
Grant	Rockford, Ill.	Wells	Government	No	Emergency
Greenleaf	Chickamauga Park	See Forrest	Municipal	Yes	Constant
Greene	Charlotte, S. C.	Catawba River	Municipal	Yes	Constant
Hancock	Augusta, Ga.	Savannah River	Municipal	Yes	Constant
Humphreys	Accotink, Va.	Accotink Creek	Government	Yes	Constant
Jackson	Columbia, S. C.	Congaree River	Municipal	Yes	Constant

Johnson	Jacksonville, Fla.	Wells	Government	No	None
Kearney	San Diego, Cal.	Morena and Otay Reservoir	Municipal	Yes	Constant
Knox‡	Stithton, Ky.	Mill Creek	Government	Yes	Constant
Las Casas	San Juan, P. R.	Rio Peidras	Municipal	Yes	Constant
Lee	Petersburg, Va.	Appomattox River	Municipal	Yes	Constant
Lewis	American Lake, Wash.	Springs	Government	No	Intermittent
Logan	Houston, Tex.	Wells	Municipal and Government	No	Intermittent
McArthur	Waco, Tex.	Brazos River	Municipal	Yes	Constant
McClellan	Anniston, Ala.	Springs	Municipal	No	Constant
Meade	Admiral Jc., Md.	Patuxent River	Government	Yes	Constant
Merritt	Tenafly, N. J.	Hackensack River	Private Co.	Yes	Constant
Mills	Garden City, L. I.	Wells	Government	No	None
Newport News	Port of Embarkation, Va.	Warwick River	Private Co.	Yes	Constant
Norfolk	Port Terminal, Va.	Impounding Res.	Municipal	Yes	Constant
Pike	Little Rock, Ark.	Arkansas River	Private Co.	Yes	Constant
Sevier	Greenville, S. C.	Little Mountain Creek	Municipal	No	Constant
Shelby	Hattiesburg, Miss.	Wells	Government	No	None
Sheridan	Montgomery, Ala.	Wells	Municipal	No	None
Sherman	Chillicothe, Ohio	Wells	Government	No	Constant
Stanley	San Antonio, Tex.	Wells	Government	No	Constant
Travis	San Antonio, Tex.	Wells	Private Co.	No	None
Wadsworth	Spartanburg, S C..	Lawson's Fork	Municipal	Yes	Constant
Wheeler	Macon, Ga.	Ocmulgee River	Municipal	Yes	Constant
Upton	Yaphank. L. I.	Wells	Government	No	None

* In all cases filtration is preceded by coagulation.
† Part of supply from surface source is chlorinated.
‡ Camp under construction June 1, 1919.

The use of liquid chlorine for the disinfection of the water supplies at the camps was almost universal. Table 6 contains a list, as an example, of the 48 large camps, with a statement showing whether or not disinfection was employed regularly, intermittently or on one or more occasions of emergency. In the smaller camps a larger percentage of ground water supplies was utilized. Disinfection was employed at 11 out of 28 establishments of the Aviation Section, utilizing ground water sources developed by the government, at two out of eight ground water sources developed by nearby municipalities and at all surface water supplies (two developed by government, fifteen by municipalities) except one field, supplied from the City of Washington.

B. coli has been frequently found in several of the ground water supplies where extended investigations by competent persons have shown that dangerous contamination was improbable, and these supplies were intermittently chlorinated. In practically all camps, the presence of B. coli in the water supply was demonstrated immediately after the completion of the systems, due probably to the entrance of dirt and foreign matter into the wells and distribution systems during construction. In one camp a sharp outbreak of diarrhoea occurred in February, 1919, among men who were quartered in one section of the camp in which new distributing pipes were being laid. The water at its source and throughout the other sections of the camp was of excellent quality, while that in the area in question was highly polluted. Careful investigations proved beyond a doubt that the infection was introduced into the distribution system during the laying of the new pipes. In some camps, where a large proportion of the distribution systems consists of wood pipe, there have been many blowouts and repairs, thus causing a more or less frequent recurrence of conditions prejudicial to the quality of the water supply. Careful chlorination has been necessary, and in most cases accomplished, in instances of this type.

The application of chlorine under the many and varied conditions encountered has indicated that the equipment for this purpose is not yet ideal, and it is manifest that careful and trained operators are necessary in order to accomplish disinfection successfully. Doses ordinarily ranged from 0.25 to 1.0 part per million but in two camps regular doses of from 1.25 to 1.6 parts per million are used, with maximum doses as high as 3 parts per million. An effort has been made to maintain duplicate equipment and spare parts at each installation

and occasional failures of machines to function properly have justified this policy.

Laboratory control and determination of quality. Laboratory facilities in surprisingly large array have been available in connection with the sanitation of all military establishments of the United States, both at home and abroad. The important place of the laboratory in military medicine and hygiene has been fully recognized and demonstrated during this war. Indeed it may be said that the development and utilization of the laboratory make one of the most striking and significant forward steps in the control of infectious disease and the conduct of practical sanitation.

At least 104 laboratories have been developed and maintained in continental United States by the Medical Department of the army for such length of time during the emergency as has been necessary. This number is comprised about as follows:

Departmental laboratories, permanent. (Eastern and Northeastern,* Southeastern, Southern, Central and Western)	5
Recruit Depot laboratories, permanent. (Fort Slocum, Fort McDowell, Columbus Barracks, Jefferson Barracks, Vancouver Barracks)	5
Port of Embarkation laboratories	2
Base Hospital laboratories (approximately)	48
General Hospital laboratories (approximately)	43
Total	104

* At Army Medical School, Washington, D. C.

In addition to those just enumerated, there are two departmental laboratories, one in Hawaii and one in the Philippine Islands.

In Europe a very large number of general and special laboratories was developed and maintained to serve the American Expeditionary Forces. Fully one-half of the entire laboratory personnel of the army saw service in Europe and the number of general laboratories abroad was fully equal to that at home. In addition, a considerable number of laboratories for water supply control work alone was provided. There were three permanent or fixed large laboratories in Engineer Corps buildings and six other fixed laboratories in Medical Department buildings. Furthermore there were ten mobile laboratories, four of which were mounted on trucks and six were contained in specially devised chests. These laboratories were all operated by

Sanitary Corps personnel under the direction of the Engineer Corps. In the 40, more or less, divisional laboratories maintained and operated by the Medical Department, Sanitary Corps officers were stationed in charge of water supply.

Practically all of the laboratories of the Medical Department have been fully equipped for making bacteriological examinations of water, milk, sewage, etc., according to the standard methods of the American Public Health Association, and those of the Army, both virtually identical. A few laboratories have been equipped to perform chemical examinations of water, milk, sewage, etc., both mineral analyses and sanitary, so-called. Of the fourteen permanent army laboratories, five at least are equipped for this chemical work, and in general, for the conduct of investigational work of considerable scope. Certain base and general hospital laboratories have been similarly equipped. A notable example of such provision for the investigation of sanitary engineering problems and the conduct of the practical sanitation of an army post is the sanitary section of the base hospital laboratory at Camp Meade, Md. This has been equipped to perform chemical and bacteriological work in connection with the examination and analysis of water, milk, foodstuffs, sewage, grease, various waste products and the materials and supplies employed in the control and operation of water purification and sewage treatment works. It is operated under the immediate supervision of Sanitary Corps officers trained and experienced along this line of work. In this laboratory, during the year or more of its existence, hundreds of samples of water, sewage, milk, ice cream, soft drinks and miscellaneous products and materials have been examined chemically and thousands of samples have been examined bacteriologically.

Laboratory methods in the army have been fully standardized and a very complete manual of procedure has been published. It is known as "Medical War Manual No. 6, Laboratory Methods of the United States Army." The first edition is dated 1918. A second edition, thoroughly revised, was published early in the current year. This manual is a highly creditable enterprise for which the Division of Infectious Diseases and Laboratories, by which it was compiled, deserves the highest commendation.

A form for recording and reporting the results of the bacteriological examination of individual water samples has been recently devised by the division for use by all army laboratories. As a matter of possible interest, this form is presented herewith.

Bacteriological examination of water

From.....
.....Laboratory
.....1919
To.....
.....
.....
.....
Sample from.....
Date collected.....1919
No.....Date examined.....1919
Appearance.....Sediment.....

AMOUNT OF WATER	LACTOSE BROTH, GAS PER CENT		ENDO		LACTOSE BROTH, GAS PER CENT		ORGANISMS
	Hours		Hours		Hours		
	24	48	24	48	24	48	
cc.							
0.1							
1							
10							
10							
10							
10							
10							

Cols. per cubic centimeter after 24 hours at 37°3. on..... agar.....
Rec. cols. per cubic centimeter after 24 hours at 37°C. on litmus lactose agar.....
Voges-Proskauer.....
Methyl red.....
Remarks:.....
.....
.....

NOTE: One copy of every report of examination of water will be forwarded to the Surgeon General.

All analytical work will be done in accordance with the latest Standard Methods for Examination of Water and Sewage of the American Public Health Association. D-274

The Maintenance and Repair Branch of the Construction Division, which has been charged with the operation of water and sewerage works in all army camps, has developed two or three laboratories in

which chemical and bacteriological examinations of water, sewage and other materials have been made. These utilities laboratories have been installed for the immediate purpose of controlling water filtration operations, but in some instances, as at Camp Meade, they have been extended in scope to permit of investigations of sewage treatment and other problems.

In connection with its extra-cantonment activities, the United Stages Public Health Service developed some 40 bacteriological laboratories, all of which were equipped for water examination work. These laboratories have contributed generously in all problems relating to the safety of drinking water supplies, not alone in extra-cantonment zones but within military reservations as well.

Red Cross laboratories have also generously extended their aid in the practical sanitation of army camps, including the determination of the quality of water supplies and the production of the hygienic safety thereof.

Health of posts as related to the water supply. It is of course now well recognized that the so-called water-borne diseases (typhoid fever, cholera, dysentery, certain diarrhoeas, etc.) are not conveyed by water alone. Milk and other foods, flies and perhaps certain other insects, and possibly still other factors less significant are, together with water, responsible for this group of diseases. The program of army hygiene and sanitation has been laid out and so conducted as to eliminate, to the fullest possible extent, all of these factors.

In general, this program of control of disease has comprised two great methods of attack: (a) the method of direct control by the immunization of the individual; (b) the method of mass control by the control of the environment.

Practically every soldier in the army and as far as possible the civilian employees at army posts have been systematically vaccinated against typhoid fever. Cholera has been so completely controlled for many years in this country by quarantine and other methods that it has not been considered necessary to vaccinate against this disease. It is reassuring, however, to realize that such a means of control has been developed and is available whenever necessary. A successful vaccine to protect the individual against dysentery (in the causation of which several strains of bacteria and an amoeba are concerned) has not yet been developed.

It has been the object of this discussion to outline the control of the environment of the soldier, as related to the provision of a safe

water supply and the precautions which have been and are being taken to insure supplies of satisfactory quality. The control of flies and other insects, the provision of clean and suitable foods, the attention which has been given to other important features of environmental control would indeed make an interesting story, but do not fall within the scope of this paper.

Experience in the army and elsewhere seems to show that vaccination against typhoid fever cannot certainly protect all individuals against massive infections or doses of virulent bacteria, especially when such infective material is suddenly encountered, as with a recently and grossly contaminated water or food supply. The conclusion which must be drawn from this fact is that sanitation cannot concern itself with the control of one factor only in the spread and conveyance of diseases or any particular disease, but every known avenue of infection must be blocked, every known means of control must be utilized. This principle has been most consistently applied in army sanitation, with results which have been nothing short of epochal.

During the period September, 1917–April, 1919, with an average strength of more than 2,000,000 men in the army in posts within the United States, there occurred but 213 deaths from typhoid fever and 42 deaths from dysentery. A large proportion of these cases was comprised of men passing through the incubation stage of these diseases at the time of their entrance into the military service. If conditions similar to those which prevailed during the Civil War had prevailed in our army during the recent period under consideration, the numbers of deaths from typhoid fever and dysentery in this group of soldiers would have been approximately 51,000 and 64,000 respectively. These values are about 240 and 300 times the corresponding figure for the recent period in question. Similarly, if the incidence of typhoid fever and for dysentery had been the same as for the Spanish American War the deaths would have numbered 68,000 and 6400 respectively, or 1620 and 150 times respectively, the actual deaths which did occur from these two diseases.

The following reference to the prevalence of typhoid fever in the American army and the general manner of its control has been abstracted from the report of the Surgeon General, U. S. Army, 1918:

> Since 1911, the Surgeon General's reports have each year represented an increasing amount of convincing evidence of the value to the army of com-

pulsory antityphoid inoculation. In 1917 this method of protection was of course tested on a much greater scale than ever before, but the results have justified the previous conclusions as to its value. Substantial protection has been secured not only against typhoid, but also against paratyphoid A and B by use of the triple typhoid vaccine adopted soon after the declaration of war.

It will be noted in the statistical part of this report that during the year 1917 there were 297 cases of typhoid; 13 cases of paratyphoid A; 7 cases of paratyphoid B. A large proportion of the cases occurring in this country were in men who were in the incubation period of the disease on their entrance into the military service. The reports of the cases which occurred in France indicate that almost all the patients had escaped receiving the typhoid prophylactic.

During the Spanish War of 1898 the admission rate for typhoid was 141 per 1000 and the death rate 14 per 1000. If this experience had been repeated in this war, for each 1,000,000 men there would be 140,000 cases of typhoid and 14,000 deaths. It can not be claimed that all of our protection from such a calamity is due to vaccination, as sanitation had much effect, but enough cases are occurring in spite of all precautions to show that there is constant danger of infection and constant need of protection by vaccination.

Recent experiments conducted at the Army Medical School have resulted in the perfecting of an oil vaccine modeled after the French vaccine, by which a complete immunization can be given in one dose. This is a distinct practical advance as an administrative measure, as it saves time and labor. A full report of the work of the Army Medical School is presented elsewhere.

Examination of all food carriers has been made for carriers of the typhoid group of organisms, and carriers found have been excluded from food handling. Where possible these carriers have been sent to the Walter Reed General Hospital for study and treatment. One cook whose urine was practically a pure culture of typhoid bacilli was found to have a pyonephrosis on one side. His kidney was removed and he made a complete recovery as a carrier. Two gall-bladder typhoid carriers have been operated on for cure by removal of the gall bladder and are still under observation.

* * * * * *

The great reductions in disease are those brought about by improved sanitation. Diarrhea and dysentery are reduced from 244,000 to 11,000, due to treatment of feces and fighting the fly. Typhoid fever is reduced from 10,000 to 225 by keeping down the fly and especially by protective inoculation; typhoid, the former great scourge of armies, has become as negligible as small pox. Malaria has been reduced from 167,000 to less than 2000 due to elimination of mosquito breeding areas.

A most interesting bulletin, designated Circular No. 69 and entitled "Typhoid-Paratyphoid Fevers" was issued under date of February 17, 1919, by the Chief Surgeon, American Expeditionary Forces. From this publication the following extracts are quoted as a matter of interest, and as showing the effect of massive doses of infectious material:

II. Summary of typhoid-paratyphoid incidence in the American expeditionary forces. In order that all medical officers in the American Expeditionary Forces may have a somewhat comprehensive view of the occurrence of these evers in the American Expeditionary Forces the following brief review is presented.

(a) From June 1, 1917, to June 1, 1918, but few cases occurred. The rate was well within the limits to be expected, in view of the sanitary conditions under which the troops were of necessity living. The cases were sporadic and only occasionally did secondary cases develop.

(b) In July, 1918, a replacement unit consisting of 248 men from Camp Cody, N. M., reached England with typhoid prevailing extensively; 98 men, or 39.5 per cent, had typhoid and the case death rate was 8.42 per cent. It was evident from the investigation that the men were exposed to infection through contaminated drinking water while en route to the port of embarkation in the United States. The unit had been vaccinated a few months prior to the occurrence of the epidemic. Most of the patients presented the typical clinical features of typhoid. The percentage of positive bacteriological findings from the blood, feces and urine was low, as no laboratory work could be done until late in the course of the disease.

(c) In August, 1918, a small but severe epidemic occurred in a detachment of engineer troops stationed at Bazoilles. In this unit fifteen cases of typhoid occurred with a death rate approximating 10 per cent. Typhoid was endemic in the civil population and the epidemic was very definitely traced to a cook in the mess of this engineer detachment, who remained on duty as cook for five days after the onset of the symptoms. The epidemic was recognized in its early stages and in all patients the disease was confirmed bacteriologically by positive cultures from the blood and feces.

(d) During the Chateau Thierry offensive diarrhoeal diseases were very prevalent in the troops engaged (approximately 75 per cent). It was demonstrated bacteriologically in this area, that the prevailing intestinal diseases were simple diarrhoea, bacillary dysentery, typhoid and paratyphoid A and B. The sick and wounded from this sector were evacuated to base hospitals in various parts of France. Very soon thereafter this office began to receive reports of cases of typhoid, paratyphoid and bacillary dysentery from base hospitals. In practically all instances the patients had been evacuated from the Chateau Thierry sector. The high incidence of intestinal diseases in this sector was due to the entire disregard of the rules of sanitation. "Military necessity" and the impossibility of supplying auxiliary labor troops, at that time prevented immediate police of the battlefields. In some of the cases involved in this series, the diagnosis of dysentery or typhoid was made by the pathologist at autopsy. The percentage of positive bacteriological findings was low as the correct diagnosis, if made, was not usually arrived at until late in the course of the disease.

(e) Both dysentery and typhoid-paratyphoid fevers were demonstrated to have prevailed to some extent in our troops after the St. Mihiel offensive, but the epidemics of influenza and pneumonia prevailing at that time overshadowed all other medical admissions.

(f) Following the offensive in the Argonne sector, typhoid and paratyphoid began to be reported from practically all divisions engaged in that offensive.

It is quite evident that the initial cases were due, in a large part, to drinking infected water. The initial cases, however, in large part were not, in most instances, promptly diagnosed and secondary cases from contact began to occur. In some divisions either the initial exposure was not great, the organizations were under good discipline, or the medical officers had a proper conception of their duties and responsibilities and but few cases occurred. In other instances the contrary was true and many cases have occurred. As examples of the two extremes may be cited the — Division in which five cases occurred between October 1, 1918, and February 1, 1919, and the — Division in which 115 cases occurred in the same period.

More than 300 cases of typhoid-paratyphoid may be attributed to the Argonne offensive. Eight hundred and seventy-four typhoids and paratyphoids have been reported in the American Expeditionary Forces since October 1, 1918. The percentage of confirmatory laboratory diagnoses has been low on account of the fact that the clinicians frequently failed to suspect the disease in its early stages.

(g) A small but severe epidemic occurred in the Joinville concentration area in December and January. In a group of Medical Department units (evacuation and mobile hospitals and sanitary trains) concentrated there 75 cases occurred with a case death rate of approximately 20 per cent. The cases were suspected in the early stages of the disease and the percentage of positive findings by culture of urine or feces has been greater than 75 per cent. The cause of this epidemic has not been completely analyzed as yet, but there is but little question that it was due to the use of infected drinking water.

VII. Prevention and control of typhoid and paratyphoid fevers. Vaccination is a partial protection only and must be re-enforced by sanitary measures.

* * * * * *

Remember: That all water in France is regarded as contaminated unless it is under constant supervision of water supply personnel. See that G. O. 131, G.H.Q., 1918, is carried out. Don't give orders only; personally assure yourself that chlorination is properly carried out. The responsibility ultimately falls upon those charged with sanitary control and not upon the enlisted man who mixes the hypochlorites of lime with the water. Study the means of prevention of drinking at unauthorized sources. The best way to do this is to see that an adequate supply of supervised water is conveniently available, wherever men work or live. Other means are the marking of water points; the removal of faucets; the placing of guards, and last but most important, the education of the men.

The following extracts from two monthly reports of an officer on duty as a camp sanitary engineer will serve to call attention to the necessity for eternal vigilance in the operation of water purification plants (especially where the raw water is grossly and immediately contaminated with untreated sewage) and the very real danger which must lie in any short circuiting of treatment.

During the period, ... 1918, on at least five separate occasions, considerable volumes of water passed from the purification plant without receiving any dose of chlorine whatever, and on at least one other occasion the dosage was entirely inadequate for disinfection. In all, during the days in question, it appears that fully 750,000 gallons of water passed from the plant either without any chlorine treatment whatsoever or with entirely insufficient dosage. No investigation has yet been made of the continuity of chlorine treatment prior to .....

* * * * * *

The filters cannot be relied upon for effective disinfection due to the coarseness of the sand, to the seriously polluted water which requires treatment, to the heavy turbidity which appears at times of storm and to the inadequacy of the coagulating and subsiding tanks at such times. In fact, in recent years, dependence has rarely been placed solely upon filters of any sort, for a desirable and perhaps necessary degree of bacterial removal.

Under date of ..... 1918, ..., M. C. reported the positive presence of B. dysenteriae (Shiga type) in a sample of laboratory tap water, taken at the Base Hospital on ..... The number of colonies developing on agar plates incubated for 24 hours at 37°C. was 5 per cubic centimeter. Five fermentation tubes, each receiving 10 cc. of the sample, showed no gas in 24 hours, but three showed gas in 48 hours. One tube inoculated with 1 cc. of the sample failed to show gas in either 24 or 48 hours. A memorandum on the report of the samples reads as follows: "Endo colonies transplanted to Russell's medium—no change in medium. Agglutination occurred with one of the transplants with Dysentery serum of the Shiga type."

On the same date, B. dysenteriae were reported in a sample of chlorinated water taken from a tap on one of the pumps at the high service pumping station on ..... The number of colonies developing on agar plates incubated for 24 hours at 37°C. was 18 per cubic centimeter. Five fermentation tubes each receiving 10 cc. of the sample showed no gas in 24 hours and in one tube only was gas present after 48 hours of incubation. The tube inoculated with 1 cc. of the sample failed to show gas in either 24 or 48 hours. A memorandum on the report of this sample was as follows: "Endo-negative colonies on Russell's medium—no change. Agglutination with dysentery serum of Shiga type. One tube agglutinates with the Flexner type."

It is significant that cases of dysentery appeared in ..... on .... 1919. During ..... there occurred a considerable number of cases of dysentery, both recognized and reported as such and unrecognized and unreported. The history of this disease is fully set forth in the monthly report for ..... 1918 of ....., camp epidemiologist.

* * * * * *

With the improved operation of the purification plant as respects chlorination, the rather serious epidemic of dysentery and diarrhoea occurring in ..... was promptly checked and so effectively that only one case of dysentery was reported during ..... In ..... there were reported 11 cases of dysentery and fully 100 cases of diarrhoea which gave ground for suspecting the existence of mild or moderate bacillary dysentery. There

were many cases of unreported diarrhoeas throughout the camp (See .... report of ....., camp epidemiologist).

With respect to the matter, ..., in his ..... report, says: "A single case of dysentery of undetermined type occurred, in contrast with the record of dysentery for ....., and abundantly justified our views of the causation of the ..... cases (infected drinking water due to a breakdown in the chlorination plant). The water reports during ..... have been excellent and the absence of diarrhoeal diseases has likewise been noteworthy."

Some lessons taught by recent army experience. Holding in review the various circumstances and conditions which have been obtained with respect to the control of the quality of water supplied to our army camps, especially in the United States, it would appear to the authors that the following general conclusions, which ought to govern future practice and procedure, may properly be drawn:

1. The variability in bacteriological quality which has been observed with respect to a considerable number of ground waters supplies has shown that frequent examinations should be made of samples collected from different points in the water supply system. This should be the case, regardless of the cause of the variation in quality. This variation may be due to differences in intensity of contamination of the water itself or to disturbances to the distributing pipe system on account of breaks or extensions, or to disturbances caused by repairs of well casings, etc.

2. Unless a ground water supply can show consistently good quality with consistently thorough laboratory examinations throughout a considerable period of time, it should be regarded with suspicion and treated accordingly.

3. Except under extraordinary circumstances, involving exceedingly successful design and construction and the most vigilant and intelligent operation, the effluents of rapid sand filter plants treating waters polluted with fecal wastes to a significant degree cannot be considered to be consistently safe and should receive further systematic treatment, as by adequate chlorination.

4. An extraordinary inefficiency and lack of intelligence is too frequently to be noted with respect to the operation of rapid sand filter plants, especially those of municipalities, and of these, naturally, the smaller communities in which the authorities do not recognize the value of expert services and the relative economy of the highest skill.

5. All water supplies, from whatever source, should be regarded as potentially unsafe and should receive adequate disinfection unless or until, through a sufficient period, their satisfactory quality without disinfection is consistently demonstrable through comprehensive laboratory examinations.

6. All chemical dosing apparatus of whatever kind must be considered at the present time as innately insubstantial and liable to breakdown. Such apparatus, if proposed or required for continuous service, must therefore be invariably installed in duplicate and in some cases in multiple units and its operation should be under constant observation.

7. The required dosage of disinfectant, whether that disinfectant be liquid chlorine employed at a large purification plant or calcium hypochlorite employed in a Lyster bag, must be determined and that dosage should be adjusted, at least approximately, to variations in character and composition of the supply undergoing treatment.

8. In non-immunized communities all water supplies and in thoroughly vaccinated communities all water supplies which are subject to even moderate contamination must be regarded as having utmost hygienic significance. There must be at least one competent agency charged with the immediate duty and responsibility of guaranteeing a safe, wholesome and aesthetically satisfactory water supply to every community. In the army, as shown herein before, there are several agencies more or less independently charged with this duty. The principle has found objection on the part of some on the ground that "what is everybody's business is no one's business." Because of the direct personal responsibility which the army enjoins, this objection cannot apply as it might in civil affairs, and there have been many experiences which have demonstrated the practical value of this scheme of organization. It is not a case of divided but of coördinated responsibility. Coördinated responsibility should be made a shibboleth in civil as well as military establishments.